

C.I.E.M.A.T.

RADIOLOGICAL AND
ENVIRONMENTAL PROTECTION
INSTITUTE

OPERATIVE UNIT OF GEOCHEMISTRY AND
TRANSURANIDE IMPACT

Translated for

U.S. Department of Energy
Washington, D.C.

Translated by

SCITRAN COMPANY
1482 East Valley Road
Santa Barbara, California 93108
(805)969-2413
FAX (805)969-3439

CIEMAT/PRYMA/M5A01/3/89

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RADIOLOGICAL MONITORING IN PALOMARES ZONE
(FIRST SEMESTER REPORT OF 1989)

JULY 1989

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RADIOLOGICAL MONITORING IN THE PALOMARES ZONE
PERIOD: FIRST SEMESTER OF 1989

Radiological monitoring in the Palomares Zone has been carried during the first semester of 1989, according to the planning established in the "RADIOLOGICAL MONITORING IN THE PALOMARES ZONE PROGRAM FOR 1989" document. The activities carried out are the ones here specified and ordered by subject.

I. HUMAN MONITORING

1.1 DOSIMETRY FOR 1988 (ENDING)

The results of the analysis of urine excretion of Pu-239 + Pu-240 and Am-241 in 75 persons monitored in 1988 were reported in the second semester report of 1988. In these 75 persons the values found were smaller than the lower limits of the detection method, that is to say, negative.

In this first semester of 1989, the analysis corresponding to the other 75 persons monitored in 1988 was completed, and measurements have been taken by Alfa spectrometry of the electrodeposits resulting from the analysis of their urine. With this, the dosimetric monitoring corresponding to the 150 persons from Palomares that were revised in said year 1988 was completed.

This last group of 75 persons was composed of the ones that have been classified into the following subgroup:

- Monitored for the first time in 1988 7 persons

¹Numbers in margin indicate foreign pagination. Commas in numbers indicate decimal points.

- With several negative analyses prior to 1988 11 persons
- With only one negative analysis prior to 1988 25 persons
- With only one value positive and several negatives prior to 1988 19 persons
- With only one positive analysis prior to 1988 3 persons
- With evaluated doses 10 persons

The results of the determinations made in the urine of the 75 people who constitute the group have rendered positive values for plutonium in nine of the said persons and positive results for americium in one person that has also had positive values for plutonium.

The concentration values of Pu-239 + Pu-240 in urine are within the range 1-2 mBq/24h in 7 persons, and are 4.2 +/- 0.6 m Bq/24h and of 2.8 +/- 31.1 mBq/24H in the other two persons. The concentration of Am-241 in the only person with a positive result is of 2.3 +/- 0.5 mBq/24h.

The positive results for plutonium have been found in a person who came for an examination for the first time in 1988, one person with previously evaluated doses and seven persons that had shown negative results in several previous examinations. As a consequence of this, we consider it necessary, from the technical point of view, as well as the scientific, to have another examination before it is possible to establish the existence of internal contamination of these persons. These nine persons were used for control in 1989.

In consequence and as an annual summary corresponding

to results of the dosimetric measurements taken in the 150 persons monitored in 1988, we can indicate that in nine of said persons it was determined that there were positive values of plutonium in their urine, that in seven of them, the values are substantially closer to the limit of the detection method and it is considered necessary to have a new examination in 1989 to be able to establish the existence or absence of contamination.

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The direct determination of lung contamination by plutonium and americium, with Lung Radioactivity Counter, in the 20 persons examined for the first time in 1988, did not show signs of contamination because the measurements taken have not shown values above the system's detection limit.

1.2 MONITORING FOR 1989

The program to examine the 150 persons that will be the subject of a medical and dosimetric control has been divided, as in every year, into two periods, one between June 4 and July 12, and the other one, which it is thought will start the second half of September.

According to the priorities established in the "RADIOLOGICAL MONITORING OF THE PALOMARES ZONE" for 1989, a list has been prepared in the first instance, a nominal list composed of 181 persons classified into distinct groups according to the priorities specified in said monitoring plan.

This list, in relation to the persons living in the Palomares Zone, has been constituted according to the same criteria that have ruled and are specified in document M2A/PI002/-/86 (1). In accordance with them, 153 persons are nominated from Palomares, three from Villaricos, these

last ones belonging to a representative group which it was decided were to be monitored in 1987.

However, the Neighbors of Villaricos Association "WE EXIST" sent, dated 10-25-88, to the Director of the PRYMA Institute of CIEMAT a document, where they manifested their concerns because they considered that most workers used to recover "radioactive debris" as a result of the accident were from Villaricos. According to them, the mortality index reflected premature death caused by cancer. They requested that they be subjected to the same medical examinations as the persons from PALOMARES.

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As a consequence of the answer from the Director of the PRYMA Institute to the said association, dated 12-16-88, with copies to the Health Delegate of Almeria and to the Mayor of Cuevas del Almanzora, the Association sent a list of 144 inhabitants of Villaricos who wished to be subjected to the medical examinations. Only 26 of these indicated that they participated in the decontamination work that took place in 1966.

The study of the components of this list and the consideration that there was no appreciable contamination produced in the town of Villaricos during the accident and that there was actually no residual contamination, resulted in the determination, in principle, to subject to a medical and dosimetric monitoring during 1989 only those persons, 26, that participated in the decontamination tasks. This decision was discussed with the Mayor of Cuevas de Almanzora, who agreed and was submitted to the consideration of the Nuclear Security Council, which approved its compliance.

Because of this, the list of persons who will be

medically and dosimetrically examined in 1989 includes 25 persons from Villaricos who, according to the list, participated in the decontamination. The other person that was involved in analogous activities and who was included in the 25 indicated, was already examined in 1987 when he was selected by us. He does not require another examination this year.

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As an initial summary we can indicate that in the list are included the following groups and number of persons.

1-A) Persons showing positive results for contamination in their urine in one instance.
Constituted by 31 persons.

1-B) Persons from Villaricos that have asked to be examined due to their involvement in decontamination activities at the time of the accident.
Constituted by 25 persons.

1-C) Persons that are 12 years of age and have not been examined before.
Constituted by 23 persons.

2-A) People who have had a positive result at least one time, and that have subsequently tested negative. Also, persons that have been called up for examination and have not shown up for some reason.
Constituted by 37 persons.

2-B) Persons from Villaricos who have been examined previously.
Constituted by 3 persons.

2-C) Persons under the age of 20 years with only one previous examination and testing negative.
Constituted by 4 persons.

3-A) Persons with only one examination or that despite having had more than one examination, have not been monitored in the last five years.

Constituted by 58 persons.

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The persons included in the first six groups are considered of maximum interest for an examination in this year of 1989.

The census from Palomares has not been received yet, which as has been pointed out, leads to difficulties in the estimation and identification of the persons that inhabit that zone and have not been examined at least once.

In the period encompassed between the 4th and 30th of June of this year, medical and dosimetric examinations were performed on 42 persons. Their distribution, according to the classification groups established is the following:

Group 1-A:	11 persons
Group 1-C:	10 persons
Group 2-A:	9 persons
Group 3-A:	2 persons
Companions	10 persons

1.2.1 Medical Monitoring

In the first stage of the Radiological Monitoring Program in the Palomares Zone for 1989 (2), developed in the period between 6-5-89 and 6-26-89, 42 persons have been medically examined, divided in the following manner:

Group 1-A:	11 persons
Group 1-C:	10 persons
Group 2-A:	9 persons

Group 3-A	2 persons
Not included in the list	10 persons (companions)

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In the medical examination undertaken, following the directives provided by the Security Guide number 7.4 "Basis for the monitoring of workers exposed to ionizing radiation" and the recommendations of the International Agencies, no pathology has been detected that may be attributable to the introduction of transuranide elements, coming from the residual contamination of the zone.

Below, we detail all significant findings:

Absence of change	11
Slight changes	21
Presence of pathology	10

1. DISEASES IN THE ENDOCRINE GLANDS, NUTRITION, THE METABOLISM AND IMMUNITY DISTURBANCES (240-279)*

Obesity	1
Hyperglycemia	4
Hypercholesterolemia	2
Hypertriglycerdemia	5
Diabetes Mellitus Type II	2

2. DISEASES OF THE BLOOD AND OF THE HEMATOPOYETIC ORGANS (280-289)

Ferropenic anemia	1
Macrocytic anemia	1
Leucopenia	1

* Code ICD-9th revision.

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3. MENTAL DERANGEMENT (290-319)

Depressive Syndrome	1
---------------------	---

4. DISEASES OF THE NERVOUS SYSTEM AND THE SENSES
(230-389)

Senile dementia	1
Migraine	2
Presbycusis	5
Hypermetropia	1
Hearing impairment	7
Bilateral impacted cerumen	1
Nasal obstruction because of hypertrophy of the nasal passages	1

5. CIRCULATORY DISEASES (390-459)

Varices in the lower extremities	2
Insufficient circulation in the lower extremities	1

6. DISEASES OF THE RESPIRATORY SYSTEM (460-519)

Chronic asthmatic bronchitis	1
Bronchopneumonia	1
Tonsil hypertrophy	2

7. DISEASES OF THE DIGESTIVE SYSTEM (520-579)

Gastric ulcers	1
Abdominal Hernia	1

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8. DISEASES OF THE GENITAL-URINARY SYSTEM (580-629)

Renal lithiasis	1
Urinary infection	1
Renal insufficiency	1
Microhepatia	1
Poststreptococic Nephritis	1
Azoospermia	1

9. SKIN AND SUBCUTANEOUS CELLULAR TISSUE DISEASES
(680-709)

Eczema	1
Dermatitis	1
Juvenile acne	1

10. DISEASES OF THE MUSCULAR SYSTEM AND THE CONJUNCTIVE
TISSUE (717-739)

Escapulohumeral Periarthritis	1
Generalized vertebral arthrosis	1
Cervical arthrosis	1
Postmelitococic Espondilitis	1
Arthritis-knees	1
Arthritis-small articulations	1
Epitrocleitis	1
Cervicobrachial syndrome	1
Dorsalgia	1
Lumbago	1
Lumbosciatica	1

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11. SIGNS, SYMPTOMS AND MORBID STATES POORLY DEFINED
(780-799)

Rx.- Ventricular hypertrophy	1
Rx. - Hiliar and parahilarary nodular calcification	1
Rx. - Basal atelencephalia	1
Rx. - Vascular congestion	1
Vital capacity reduction in functional breathing tests	1
Dyspnoea (shortwindedness)	1
Microscopic leucocyturia and hematuria	4
Albuminuria	1
Glucosuria	2
Increased urea serum	1

The findings listed correspond to the daily pathology found in the periodic examinations of workers, both those exposed as well as not exposed to ionizing radiation, and in our judgement there is no data that points to a morbidity specifically induced by radioactive agents.

1.2.2 Dosimetric Monitoring

Radiochemical analysis has been performed in 32 urine samples corresponding to persons examined during the month of June 1989, but the Alfa spectrometry measurements have not yet been taken to determine if there is Plutonium or Americium contamination in any of the samples. Consequently, we cannot indicate the existence or absence of contamination.

2. ENVIRONMENTAL MONITORING

2.1 Soils

In relation to soil contamination, the activities performed during this semester are specified below:

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2.1.1 Surface contamination of the Area by Plutonium

The radiochemical analysis has been undertaken to determine the concentration of Pu-238 + Pu-240 in the surface samples (5 centimeters deep) gathered, during the month of June 1988, at 29 locations in the perimeter of the "line zero" of contamination produced by the accident in 1966, and at a distance of approximately 500 meters from this line, as can be observed in Figure 1.

The results of the analysis, after the Alfa spectrometry measurement, are given in Table 1. From these

values, which correspond to 58 analyses, it can deduced that:

- The values corresponding to the concentrations of Pu-238 + Pu-240 on the surface of the soils undisturbed by cultivation and located outside the indicated "line zero" were under the detection limits (<0.002 KBq/Kg) in 11 of the 29 sampled locations.

- Values larger than 1 KBq/Kg, with a maximum of 9.9 ± 1.36 KBq/Kg have been found in six locations. In two of these locations, points 1 and 21 in Figure 1, the concentration of Am-241 is above the detection level limits as was indicated in our report for the second semester of 1988.

Two other locations, points 18 and 23 in figure 1, correspond to the dry bed of the Amanzores River. Finally, the other two locations, points 11 and 15 in figure 1, are located south of zones 2 and 5, belonging to an area where certain activities were carried out relating to the decontamination and residence of U.S. Forces, at the time of the accident.

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- Values under 1 KBq/Kg have been determined in the samples corresponding to 12 locations. In seven of the locations, the concentration of Pu-238 + Pu-240 was less than 0.1 KBq/Kg.

Based on the results obtained, it is found there is contamination by plutonium at certain locations outside "line zero" that was established at the time of the accident and at a distance on the order of 500 meters. In those locations where the contamination is greater, there may be a relation to the date of the accident. Therefore, in view of these results, we consider it necessary to obtain new

samples from the surface of the soils (5 centimeters deep) in the vicinity of these locations. Likewise we consider it is necessary to obtain surface samples outside "line zero" and up to distances of approximately 1,000 meters from the locations where concentrations greater than the detection limit have been determined.

2.2 Air

The activities during the first semester of 1989 are the following:

2.2.1 Sampling

Continuous sampling on a weekly basis in the stations that continue in operation was done in the established manner. These three stations correspond to the reference 2-2-1, 2-2 and P (urban zone). In stations 2-1 and P (urban zone), there is special equipment which collects only the particles in the inhalable fraction, that is to say those with size smaller than 10 μm .

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Seventy-eight samples have been obtained with an air volume of approximately 10,000 cubic meters each.

On the other hand, and to be used as representative of the radioactive background in Spain, the continuous weekly sampling of air in the Embalse de Santillana has continued. Twenty-six samples have been obtained, with a median volume of 300 cubic meters each.

2.2.2 Plutonium Concentration

The radiochemical analysis to determine the concentration of Pu-238 + Pu-240 in the air has been carried

out on 66 weekly samples from Palomares. All of them correspond to area P (urban zone), which is the most representative with respect to population risk.

The analyzed samples are distributed by date as followings:

Area P (urban zone):	40 samples from 1983
Area P (urban zone):	26 samples from 1988

The samples from 1983 provided values corresponding to the said area and year, since in the report for the first semester of 1986 the results of the other 12 weeks were given.

The samples for 1988 correspond to those taken at area P during the period between January 2 and July 2 of 1988, this is to say, all of the samples for the first semester of the year.

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The concentration of Pu-238 + Pu-240 during 1983, at area P (urban zone) is given in Table 2. Values corresponding to the analysis performed in this semester of 1988 have been grouped in periods of 3 or 4 weeks, to reduce the time of Alfa spectrometry measurement; the electrodeposits were performed combined with chemical treatments that have been individually performed on each weekly sample. In this table, as can easily be seen, the results of the first semester of 1986 have been included, to provide a combined picture of the whole year.

From the group of values in Table 1, it can be deduced that:

- The median value of the concentration of plutonium in the urban area of Palomares, during the year 1983, was

Area P (urban zone): $9.1 \mu\text{Bq}/\text{m}^3$

- The range of plutonium concentrations in the said urban zone, during 1983, was:

Area P (urban zone): between 0.2 and $42.2 \mu\text{Bq}/\text{m}^3$

- Both the median value and the maximum concentration of plutonium during the year 1983 stayed beneath the concentration derived in air ($5,900 \mu\text{Bq}/\text{m}^3$) for the plutonium compounds class Y, derived from the value set by Spanish legislation (3) for the limit of yearly incorporation by inhalation.

The area concentrations of Pu-238 + Pu-240 during the first semester of 1988, in area P (urban zone) are given in Table 3. Given the characteristics of the sampling method, the said concentrations are representative of the inhalable fraction.

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From these values, one can deduce an episodic situation, during the week from 2/27 to 3/5, that caused a maximum concentration of $98.9 \pm 1.1 \mu\text{Bq}/\text{m}^3$, quite above the median value of $3.7 \mu\text{Bq}/\text{m}^3$, for the other weeks of the semester.

From the group of values in Table 3, we find that:

- The median plutonium concentration in the urban area of Palomares, during the first semester of 1988 was:

Area P (urban zone): $7.4 \mu\text{Bq}/\text{m}^3$

- The weekly concentrations of plutonium, in said urban zone during the first semester of 1988 were within the range $0.2 - 98.9 \mu\text{Bq}/\text{m}^3$.
- Both the maximum and the median of the weekly concentration of plutonium, during the first semester of 1988 were less than the concentration in air, $5,900 \mu\text{Bq}/\text{m}^3$, for plutonium compounds class Y, as can be derived from the limit value of annual incorporation established in the Spanish legislation.

2.2.3 Americium Concentration

The radiochemical analysis and spectrometric measurements to determine the concentrations of Am-241 in the air have been undertaken in 40 weekly samples corresponding to station P (urban zone), taken in 1983. The chemical treatment of the radio analytical process has been applied to each sample individually, however, the electro-deposits and the measurements with Alfa spectrometry have been made in group samples corresponding to three or four weekly samples, as can be seen in the table where the results are given.

The results of the determinations undertaken are given in Table 4. From these values it is found that the concentration of Am-241 in the air, during the specified periods of 1983, was below $0.2 \mu\text{Bq}/\text{m}^3$, since the values obtained were below the detection limits of our procedure.

The risk from inhalation of Am-241 during 1983 can be considered insignificant because starting with the annual limit for incorporation by inhalation according to the Spanish legislation (3), the limit for concentration derived in air for all the compounds of Americium-214, on the average, is $2.36 \mu\text{Bq}/\text{m}^3$.

2.3 Vegetation

The activities undertaken in this respect have been the following:

2.3.1 Sampling

In accordance with the specifications established in the monitoring plan for 1989 (2) the vegetation samples and cultivated products that have been collected during this first semester of 1989 are the ones below:

- Ten samples of tomatoes and 10 samples of plants originating from three parcels in zone 2, three parcels from zone 3, three parcels from zone 5 and one parcel from zone 5-3B. These were collected in the month of January.
- One sample of olives and one sample of olive leaves from zone 2. These were collected in the month of January.

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- Six samples of tomatoes and six samples of their respective plants from greenhouses in zone 2 and two greenhouses from zone 3. These were collected in the month of May.
- Five samples of barley, representatives of the cereal crop of this year, from five parcels in zone 3. There has been no cultivation of oats in either zone 2 or zone 5. These were collected in the month of May.
- Two samples of wheat, representative of this crop in this year, originating from one parcel in zone 3 and from one parcel in zone 5. There has been no cultivation of wheat in zone 2. They were collected in the month of May.
- Seven samples of watermelons and seven samples of their corresponding plants, representative of this crop in this year and originating from three parcels in zone 2, two parcels in zone 3 and two parcels from zone 5. They were collected in the month of June.
- One sample of melons and one sample of a plant coming from a parcel located in zone 3. It was monitored in June.

2.3.2 Contamination by Plutonium

During this period, measurements were made by Alfa spectrometry in 35 samples of crops made in 1987 and in 60 samples originating from crops obtained in 1988.

The classification with respect to species, components, and year is the following:

Year 1987

- 9 samples of barley grain, 9 of hull, and 9 of their respective straw stems
- 2 samples of wheat grain, 2 of hull, and 2 of their respective straw stems.
- 1 sample of olives and 1 of olive leaves.

Year 1988

- 10 samples of tomatoes, 10 of washed tomatoes, and 10 of their respective vines.
- 9 samples of watermelon, 9 from the rest of the unwashed fruit, and 9 from their respective vines.
- 3 samples of alfalfa.

The results corresponding to the analysis of the cereals and olives for 1987 are specified in Tables 5,6,7 and 8, according to the zone to which these crops belong. From the said values, it can be deduced that, in general, they show contamination of Pu-238 + Pu-240 and their values are related to the values of the residual contamination where they have been cultivated, the magnitude being, for barley, less in the grain than in the hull or stem.

The median values corresponding to the samples that have yielded concentrations above the minimum detectable limits of our method (L.I.D. = 0.002 Bq/Kg) are the following:

Barley

Zone 2-0

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Grain	=	15.47	Bk/kg
Hull	=	4402	Bk/kg
Stem	=	121	Bk/kg

Zone 2

Grain	=	1.9	Bk/kg
Hull	=	183	Bk/kg
Stem	=	10.7	Bk/kg

Zone 3

Grain	=	0.67	Bk/kg
Hull	=	26.9	Bk/kg
Stem	=	0.002	Bk/kg

Wheat

Zone 2-0

Grain	=	7.6	Bk/kg
Hull	=	9.0	Bk/kg
Stem	=	3.7	Bk/kg

Zone 5

Grain	=	2.4	Bk/kg
Hull	=	92.3	Bk/kg
Stem	=	0.94	Bk/kg

The highest contamination values are found in the hull, which is the throw away part, including for the feeding of animals, and demonstrate that the contamination is external and that re-suspension plays a key role. On the other hand, these higher contaminations correspond to zone 2-0, the one with the highest level of residual contamination, where only about two hectares have been dedicated to cultivation.

However, the use of barley and straw for animal feeding, its factor of transference by ingestion (10^{-4} - 10^{-5}) and the transference factors to animal food products, renders the risk that they are practically undetectable.

The risk associated with the use of wheat for direct consumption by humans can be considered very small, when comparing its concentration with the limits for official annual incorporation for ingestion, which is of 200,000 Bq for plutonium compounds of class Y.

- The olives gathered in zone 2 showed a concentration of 1.1 Bq/kg and the olive leaves of 15.4 Bq/kg.

The results obtained for the samples of tomatoes cultivated in greenhouses during 1988 are given in Tables 9 and 10. A great part of the values obtained are under the limit of detection of our method, especially in the edible fruit once this is washed.

The median values corresponding to the diverse components determined in each of the zones with greenhouses are as follows:

Tomatoes

Zone 2

Fruit	=	0.04	Bk/kg
Washed Fruit	=	0.0002	Bk/kg
Plant	=	0.20	Bk/kg

Zone 3

Fruit	=	0.30	Bk/kg
Washed Fruit	=	0.03	Bk/kg
Plant	=	0.55	Bk/kg

The order of magnitude of the contamination is minor, from the point of view of risk, since the official annual limit for incorporation by ingestion of the plutonium compounds of class Y is 200,000 Bq.

The values corresponding to the concentration of Pu-238 + Pu-240 in the alfalfa samples collected in 1988 are in Tables 11 and 12. These values show that only one sample, of the three collected during the year, shows plutonium contamination with values higher than the detection limit of the sampling method. Said value, 2.3 +/- 0.5 Bq/kg, and the utilization of the produce for animal feeding indicate that the risk is minor.

The results of the radiochemical analysis performed on the watermelon samples of said cultivation during the year 1988 are specified in Tables 11, 12, and 13.

From these values, it is deduced that in the edible part of the watermelon there is no contamination from plutonium, since only one sample from zone 2 has given a concentration of 0.05 Bq/Kg and this is so small that even if it was not due to contamination of the sample, its values do not imply any risk.

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A slight concentration of plutonium has been found in the unwashed peel of a sample of watermelon from zone 2. Its is 3.5 Bq/Kg and we consider it due to external contamination of the sample. This value does not imply any appreciable risk.

The vines of the watermelon have shown contamination in three samples, two from zone 2 and one from zone 3, with a median value of 4.6 Bq/Kg. These plants are in contact with the soils, and we think that the contamination is external.

2.3.3 Americium Contamination

The analysis to determine the contamination by Am-241 has been undertaken in 10 samples of tomatoes and 10 samples of their respective vines collected in the month of January, 1989 in three parcels in zone 2, three parcels in zone 5 and one parcel in zone 5-3B. The analysis has been carried out in duplicate and in both washed and unwashed tomatoes from each sample. Also, the samples of olives and olive leaves collected in zone 2 in the same month of 1989 were analyzed.

The results are given in Table 14, 15, 16 and 17. From the values indicated in these tables it is deduced that none of the samples analyzed showed contamination in an amount higher than the detection limit of our methods.

3. PARTICIPANTS

The data, specifications, and conclusions in this report were given by the following persons from CIEMAT:

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Senior Technicians: Emilio Iranzo, Angel Bellido, Santiago Castano, Maria Asuncion Espinosa and C. Emma Iranzo.

Technicians: Camila Blanco, Ludivina Borrego, Maria del Carmen Guzman, Francisco Moreno and Mariano Montoya.

4. REFERENCES

- (1). - Radiological Monitoring in Palomares: Program for 1986, M2A/PJ002/--/86, January 1986.
- (2). - Radiological Monitoring in Palomares: Program for 1989. CIEMAT/PRYMA/GIT/M5A01/2/89.
- (3). - Rules for Protection Against Ionizing Radiation. B.O.E. num. 13, 15 January 1988.

PALOMARES AREA: ORIGINAL CONTAMINATION LEVELS

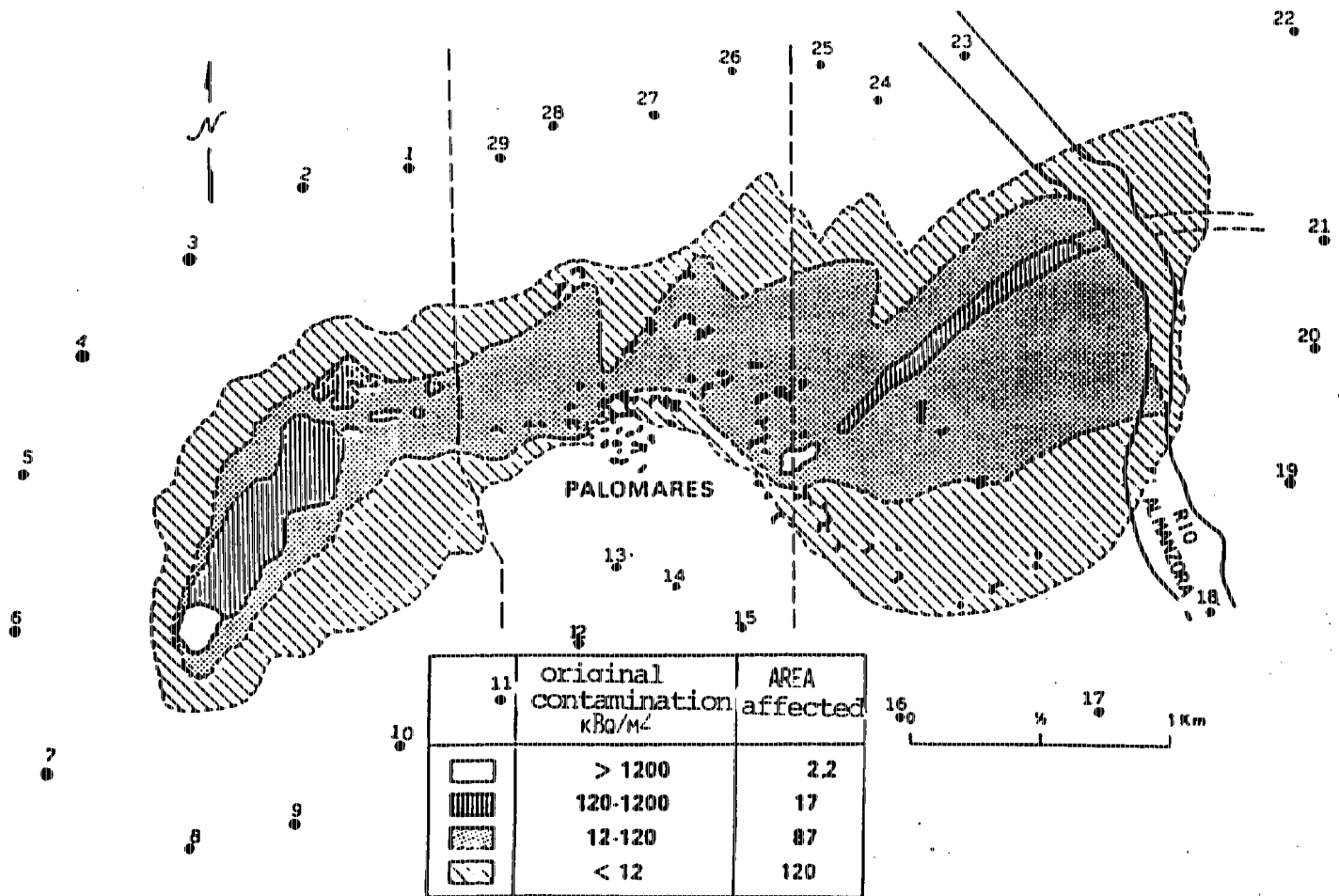


Figure 1. SURFACE SOIL (5 CM) SAMPLE LOCATIONS IN JUNE 1988.

TABLE 1. CONCENTRATION OF PLUTONIUM IN THE SURFACE SOILS
IN PALOMARES IN 1988

<u>LOCATION</u>		<u>ACTIVITY CONCENTRATION</u>	
<u>ZONE</u>	<u>POINT</u>		
LIMÍTROFE 2	1		1.9 ± 0.3
" "	2		≤ 0.002
" "	3		0.023 ± 0.005
" "	4		≤ 0.002
" "	5		0.034 ± 0.005
" "	6		≤ 0.002
" "	7		0.086 ± 0.014
" "	8		0.019 ± 0.003
" "	9		≤ 0.002
" "	10		≤ 0.002
" "	11		9.09 ± 1.36
LIMÍTROFE 5	12		0.42 ± 0.07
" "	13		0.306 ± 0.051
" "	14		≤ 0.002
" "	15		1.18 ± 0.18
" "	25		≤ 0.002
" "	26		0.106 ± 0.019
" "	27		≤ 0.002
" "	28		0.130 ± 0.023
" "	29		0.065 ± 0.012
LIMÍTROFE 3	16		≤ 0.002
" "	17		0.086 ± 0.016
" "	18		2.55 ± 0.38
" "	19		≤ 0.002
" "	20		0.094 ± 0.017
" "	21		7.28 ± 1.09
" "	22		0.157 ± 0.028
" "	23		1.87 ± 0.29
" "	24		≤ 0.002

THESE SAMPLES CORRESPOND TO THE SURFACE LAYER OF 5 CM. IN
THICKNESS

TABLE 2. ACTIVITY CONCENTRATION OF ^{239}Pu + ^{240}Pu IN THE AIR
SAMPLES FROM PALOMARES

PERIOD	CONCENTRATION ^{239}Pu + ^{240}Pu , $\mu\text{Bq}/\text{m}^3$		
	Building 2-1	Building 2-2	Building P (urban zone)
31-12-82 to 08-01-83			≤ 0.2
08-01 to 29-01-83			1.4 ± 0.3
29-01 " 05-02-83			0.81 ± 0.48
05-02 " 26-02-83			7.8 ± 1.3
26-02 " 05-03-83			0.78 ± 0.44
05-03 " 26-03-83			≤ 0.2
26-03 " 02-04-83			3.1 ± 0.4
02-04 " 30-04-83			4.3 ± 0.6
30-04 " 07-05-83			2.5 ± 0.7
07-05 " 28-05-83			1.4 ± 0.2
28-05 " 04-06-83			1.9 ± 0.7
04-06 " 25-06-83			29.3 ± 4.7
25-06 " 02-07-83			1.7 ± 0.3
02-07 " 30-07-83			35.4 ± 5.9
30-07 " 06-08-83			4.8 ± 0.6
06-08 " 27-08-83			38.2 ± 6.5
27-08 " 03-09-83			≤ 0.2
03-09 " 24-09-83			11.9 ± 2.0
24-09 " 01-10-83			4.1 ± 0.6
01-10 " 29-10-83			42.2 ± 7.2
29-10 " 05-11-83			≤ 0.2
05-11 " 26-11-83			9.6 ± 2.2
26-11 " 03-12-83			4.8 ± 0.7
03-12 " 31-12-83			11.3 ± 1.9

TABLE 3. ACTIVITY CONCENTRATION OF ^{239}Pu + ^{240}Pu IN THE AIR SAMPLES FROM PALOMARES

PERIOD	CONCENTRATION ^{239}Pu + ^{240}Pu , $\mu\text{Bq}/\text{m}^3$		
	Building 2-1	Building 2-2	Building P (urban zone)
02-01 to 09-01-88			1.6 ± 0.2
09-01 " 16-01-88			6.4 ± 0.7
16-01 " 23-01-88			0.9 ± 0.1
23-01 " 30-01-88			0.5 ± 0.1
30-01 " 06-02-88			0.46 ± 0.08
06-02 " 13-02-88			0.43 ± 0.07
13-02 " 20-02-88			0.40 ± 0.07
20-02 " 27-02-88			5.9 ± 0.8
27-02 " 05-03-88			98.9 ± 1.1
05-03 " 12-03-88			6.1 ± 1.1
12-03 " 19-03-88			≤ 0.2
19-03 " 26-03-88			2.4 ± 0.4
26-03 " 02-04-88			3.0 ± 0.6
02-04 " 09-04-88			21.8 ± 2.8
09-04 " 16-04-88			2.8 ± 0.6
16-04 " 23-04-88			2.4 ± 0.5
23-04 " 30-04-88			6.2 ± 1.2
30-04 " 07-05-88			1.6 ± 0.3
07-05 " 14-05-88			1.6 ± 0.3
14-05 " 21-05-88			2.7 ± 0.6
21-05 " 28-05-88			1.5 ± 0.3
28-05 " 04-06-88			4.2 ± 0.8
04-06 " 11-06-88			11.1 ± 1.6
11-06 " 18-06-88			≤ 0.2
18-06 " 25-06-88			4.8 ± 0.7
25-06 " 02-07-88			4.4 ± 0.6

TABLE 4. ACTIVITY CONCENTRATION OF ^{241}Am IN THE AIR
SAMPLES FROM PALOMARES

PERIOD	CONCENTRATION ^{241}Am , $\mu\text{Bq}/\text{m}^3$		
	Building 2-1	Building 2-2	Building P (urban zone)
08-01 to 29-01-83			≤ 0.2
05-02 " 26-02-83			≤ 0.2
05-03 " 26-03-83			≤ 0.2
02-04 " 30-04-83			≤ 0.2
07-05 " 28-05-83			≤ 0.2
04-06 " 25-06-83			≤ 0.2
02-07 " 30-07-83			≤ 0.2
06-08 " 27-08-83			≤ 0.2
03-09 " 24-09-83			≤ 0.2
01-10 " 29-10-83			≤ 0.2
05-11 " 26-11-83			≤ 0.2
03-12 " 31-12-83			≤ 0.2

TABLE 5. PLUTONIUM - 239 CONTENT IN THE VEGETATION FROM
AREA 2-0 DURING 1987

SAMPLING DATE	FARM	VEGETABLE SPECIES	PART	CONCENTRATION ACTIVITY Bq/kg
14-5	A.N.N. 300 200	barley	grain	9.9 ± 1.9
"	"	"	spike	3141 ± 439
"	"	"	straw	36.2 ± 5.4
"	A.N.N. 300 220	"	grain	33.8 ± 5.1
"	"	"	spike	9702 ± 1455
"	"	"	straw	249.3 ± 39.9
"	P.T. 300 275	"	grain	3.4 ± 0.5
"	"	"	spike	363.3 ± 54.8
"	"	"	straw	77.6 ± 8.2
"	A.P.M. 375 338	wheat	grain	7.6 ± 1.1
"	"	"	spike	9.0 ± 1.5
"	"	"	straw	3.7 ± 0.6

TABLE 6. PLUTONIUM - 239 CONTENT IN THE VEGETATION FROM AREA 2 DURING 1987

SAMPLING DATE	FARM	VEGETABLE SPECIES	PART	CONCENTRATION ACTIVITY Bq/kg
26-4	M.P.P. $\frac{537}{775}$	barley	grain	2.3 ± 0.4
"	"	"	spike	209.3 ± 31.3
"	"	"	straw	10.2 ± 1.6
"	M.N.A. $\frac{700}{825}$	barley	grain	1.5 ± 0.3
"	"	"	spike	156.7 ± 23.9
"	"	"	straw	11.1 ± 1.7
10-12	M.S.N. $\frac{550}{775}$	OLIVO	fruit	1.1 ± 0.2
"	"	"	leaves	15.4 ± 2.4

TABLE 7. PLUTONIUM - 239 CONTENT IN THE VEGETATION FROM
AREA 3 DURING 1987

SAMPLING DATE	FARM	VEGETABLE SPECIES	PART	CONCENTRATION ACTIVITY Bq/kg
26-4	D.C.G. CAT. 765	barley	grain	0.96 ± 0.17
"	"	"	spike	2.6 ± 0.4
"	"	"	straw	$\leq L.D.$
"	J.C.G. CAT. 761	"	grain	0.38 ± 0.07
"	"	"	spike	51.1 ± 8.2
"	"	"	straw	$\leq L.D.$

TABLE 8. PLUTONIUM - 239 CONTENT IN THE VEGETATION FROM
AREA 5 DURING 1987

SAMPLING DATE	FARM	VEGETABLE SPECIES	PART	CONCENTRATION ACTIVITY Bq/kg
14-5	D.P.G. 1138 1025	barley	grain	0.46 \pm 0.08
"	"	"	ESPICULA	11.8 \pm 1.7
"	"	"	spike	3.6 \pm 0.7
26-4	P.C.P. 1325 825	"	grain	2.8 \pm 0.4
"	"	"	spike	9.2 \pm 1.4
"	"	"	straw	7.8 \pm 1.4
"	J.A.A. 1625 11/5	wheat	grain	2.4 \pm 0.4
"	"	"	spike	92.3 \pm 13.5
"	"	"	straw	0.94 \pm 0.16

TABLE 9. PLUTONIUM - 239 CONTENT IN THE VEGETATION FROM
AREA 2 DURING 1988

SAMPLING DATE	FARM	VEGETABLE SPECIES	PART	CONCENTRATION ACTIVITY Bq/kg
24-4	INVERNADERO (725) G.S.G. (750)	tomatoes	fruit	L.I.D.
"	"	"	washed fruit	L.I.D.
"	"	"	plant	L.I.D.
"	INVERNADERO S(975) J.S.F. (750)	"	fruit	0.008 ± 0.001
"	"	"	washed fruit	L.I.D.
"	"	"	plant	0.97 ± 0.10
"	INVERNADERO N(950) J.S.F. (850)	"	fruit	0.19 ± 0.03
"	"	"	washed fruit	L.I.D.
"	"	"	plant	L.I.D.
"	INVERNADERO O(600) F.L.L. (650)	"	fruit	L.I.D.
"	"	"	washed fruit	L.I.D.
"	"	"	plant	L.I.D.
"	INVERNADERO E(700) F.L.L. (550)	"	fruit	L.I.D.
"	"	"	washed fruit	L.I.D.
"	"	"	plant	L.I.D.

TABLE 10. PLUTONIUM - 239 CONTENT IN THE VEGETATION FROM AREA 3 DURING 1988

SAMPLING DATE	FARM	VEGETABLE SPECIES	PART	CONCENTRATION ACTIVITY Bq/kg
24-4	INVERNADERO N J.A.L.(C.A.T. 488)	tomatoes	fruit	0.10 ± 0.01
"	"	"	washed fruit	0.034 ± 0.005
"	"	"	plant	0.5 ± 0.1
"	INVERNADERO O J.N.T.(C.A.T. 228)	"	fruit	0.36 ± 0.04
"	"	"	washed fruit	L.I.D.
"	"	"	plant	0.49 ± 0.12
"	INVERNADERO E J.N.T.(C.A.T. 228)	"	fruit	0.16 ± 0.02
"	"	"	washed fruit	L.I.D.
"	"	"	plant	L.I.D.
"	INVERNADERO N J.N.T.(C.A.T. 498)	"	fruit	0.09 ± 0.01
"	"	"	washed fruit	L.I.D.
"	"	"	plant	L.I.D.
"	INVERNADERO S J.N.T.(C.A.T. 498)	"	fruit	0.80 ± 0.09
"	"	"	washed fruit	0.10 ± 0.02
"	"	"	plant	1.74 ± 0.27

TABLE 11. PLUTONIUM - 239 CONTENT IN THE VEGETATION FROM AREA 2 DURING 1988

SAMPLING DATE	FARM	VEGETABLE SPECIES	PART	CONCENTRATION ACTIVITY Bq/kg
30-5	M.S.N. PARCEL 2-2 S	watermelon	fruit(rind)	0.05 ± 0.01
"	"	"	fruit(rest)	L.I.D.
"	"	"	plant	
"	M.S.N. PARCEL 2-2 N	"	fruit(rind)	L.I.D.
"	"	"	fruit(rest)	L.I.D.
"	"	"	plant	3.5 ± 0.5
"	M.S.N. PARCEL 2-2 center	"	fruit(rind)	L.I.D.
"	"	"	fruit(rest)	0.51 ± 0.08
"	"	"	plant	6.9 ± 0.9
"	B.N.L. (950) Zone 5 limit (925)	ALFALFA		L.I.D.

TABLE 12. PLUTONIUM - 239 CONTENT IN THE VEGETATION FROM AREA 3 DURING 1988

SAMPLING DATE	FARM	VEGETABLE SPECIES	PART	CONCENTRATION ACTIVITY Bq/kg
30-5	D.S.C.PARCEL (3-1) N	watermelon	fruit(rind)	L.I.D.
"	"	"	fruit(rest)	L.I.D.
"	"	"	plant	L.I.D.
"	J.F.G.PARCEL (3-1) O	"	fruit(rind)	L.I.D.
"	"	"	fruit(rest)	L.I.D.
"	"	"	plant	L.I.D.
"	J.A.L.PARCEL (3-2) E	"	fruit(rind)	L.I.D.
"	"	"	fruit(rest)	L.I.D.
"	"	"	plant	
"	J.A.L.PARCEL (3-2) O	"	fruit(rind)	L.I.D.
"	"	"	fruit(rest)	
"	"	"	plant	3.4 ± 0.5
"	J.F.G.PARCEL (3-1) O limit	ALFALFA		2.3 ± 0.5
"	D.F.C. C.A.T. 489	"		L.I.D.

TABLE 13. PLUTONIUM - 239 CONTENT IN THE VEGETATION FROM
AREA 5 DURING 1988

SAMPLING DATE	FARM	VEGETABLE SPECIES	PART	CONCENTRATION ACTIVITY Bq/kg
30-5	B.A.S. PARCEL (5-1) N	watermelon	fruit(rind)	L.I.D.
"	"	"	fruit(rest)	L.I.D.
"	"	"	plānt	L.I.D.
"	B.A.S. PARCEL (5-1)	"	fruit(rind)	L.I.D.
"	"	"	fruit(rest)	L.I.D.
"	"	"	plant	L.I.D.

TABLE 14. AMERICIUM-241 CONTENT IN THE VEGETATION FROM
AREA 2 DURING 1989

SAMPLING DATE	FARM	VEGETABLE SPECIES	PART	CONCENTRATION ACTIVITY Bq/kg
13-1	M.S.N. (610) (770)	tomato	fruit	0.007
"	"	"	washed fruit	0.007
"	"	"	plant	0.006
"	CEMENTERIO (200) (550)	"	fruit	0.007
"	"	"	washed fruit	0.007
"	"	"	plant	0.006
"	F.L.L. (725) (625)	"	fruit	0.007
"	"	"	washed fruit	0.007
"	"	"	plant	0.007
"	M.S.N. (550) (775)	olive	fruit	0.008
"	"	"	leaves	0.007

TABLE 15. AMERICIUM-241 CONTENT IN THE VEGETATION FROM
AREA 3 DURING 1989

SAMPLING DATE	FARM	VEGETABLE SPECIES	PART	CONCENTRATION ACTIVITY Bq/kg
13-1	J.A.L. CAT 488	tomato	fruit	0.007
"	"	"	washed fruit	0.006
"	"	"	plant	0.007
"	J.F.G. CAT 780	"	fruit	0.007
"	"	"	washed fruit	0.007
"	"	"	plant	0.008
"	C.S.G. CAT 781	"	fruit	0.007
"	"	"	washed fruit	0.007
"	"	"	plant	0.007

TABLE 16. AMERICIUM-241 CONTENT IN THE VEGETATION FROM
AREA 5 DURING 1989

SAMPLING DATE	FARM	VEGETABLE SPECIES	PART	CONCENTRATION ACTIVITY Bq/kg
13-1	J.N.S. (1000) (900)	tomato	fruit	0.007
"	"	"	washed fruit	0.007
"	"	"	plant	0.007
"	B.A.S. (1150) (950)	"	fruit	0.007
"	"	"	washed fruit	0.007
"	"	"	plant	0.008
"	J.F.G. (1850) (1100)	"	fruit	0.007
"	"	"	washed fruit	0.007
"	"	"	plant	0.007

TABLE 17. AMERICIUM-241 CONTENT IN THE VEGETATION FROM
AREA 5-3B DURING 1989

SAMPLING DATE	FARM	VEGETABLE SPECIES	PART	CONCENTRATION ACTIVITY Bq/kg
13-1	PARCEL 5 - 3B	tomato	fruit	0.008
"	"	"	washed fruit	0.006
"	"	"	plant	0.006